

Developing reading comprehension: combining visual and verbal cognitive processes

■
Gary Woolley

GRIFFITH UNIVERSITY

When most children read narrative texts they actively utilise cognitive resources to comprehend by constructing appropriate mental models of story events. However, many children with poor comprehension experience difficulties due to an inability to appropriately direct attention and to effectively use the resources of working memory. As a result, their ability to construct integrated mental models of story content may be impaired. However, their reading comprehension performance can be improved when they are taught inferential reading comprehension strategies involving both verbal and visual processes to facilitate more elaborated mental modeling of narrative texts. This article discusses how such strategies can be implemented and consolidated using a metacognitive focus within a flexible multiple-strategy framework.

Introduction

The *simple view of reading* (Gough & Tunmer, 1986) provides a model to conceptualise reading comprehension as the product of two dimensions: listening comprehension and word decoding processes (Kirby & Savage, 2008). The model makes it clear that children may differ in respect to the two dimensions and, therefore, require different teaching approaches to support their reading development. For example, a number of researchers have identified the existence of children with poor decoding but with good listening comprehension and children who have good decoding skills but poor listening comprehension (e.g. Catts, Hogan, & Fey, 2003; Snowling & Firth, 1997). Poor decoders have difficulty comprehending because they often spend time and conscious effort decoding individual letters and words, where the meaning is less evident, rather than clustering words into larger meaningful wholes (Idol, 1988; Kendeou, Savage, & Van den Broek, 2009; Robinson, 2001). Thus, word decoding is necessary but not sufficient for reading comprehension and should be complemented by the development of language comprehension skills (Fielding-Barnsley, Hay, & Ashman, 2005;

Woolley, 2006). Conversely, children with good decoding skills and poor listening comprehension have language difficulties that inhibit reading comprehension and are often inappropriately placed in phonic instructional programs (Kendeou et al., 2009).

This article focuses on children with good decoding skills but with poor listening comprehension. It will discuss how elaborated mental models of narrative text promote reader comprehension. It is proposed that the efficiency of mental modeling is largely determined by the architecture of working memory and how attentional resources are allocated. It is asserted that the allocation of cognitive resources within working memory can be improved with the incorporation of visual and verbal comprehension strategies. This enables the inferential linking of information and the formation of more elaborated and coherent mental models of story content leading to improved reading comprehension. Furthermore, the article will show how the routine incorporation of multiple comprehension strategies, using a metacognitive framework, can increase students' self-regulation and reading engagement. In doing so, it will address Pressley's (2002) concern that there is a need to develop more multiple-strategy intervention programs that are rich in individual instructional components without simply having them thrown into the mix and made overwhelmingly too complex for teachers to implement.

Construction of a mental model

A mental model is a cohesive representation of the meaning of the text content (Kintsch, 1998). However, mental models do not generally retain the verbatim text information but support more flexible knowledge structures that can integrate both visual and verbal material. The construction of a mental model is a dynamic constructive process, partly determined by the interaction of the reader with the text structure and story content. Initially, the mental model is goal directed and predictions are made about upcoming story events, which may be adjusted to incorporate unexpected scenarios. Skilled comprehenders are likely to make inferences by incorporating relevant background knowledge to make sense of implicit information found within texts to enhance understanding (Pearson & Johnson, 1978; Snow, 2002; Stull & Mayer, 2007). It is asserted that, when visual and verbal processes are incorporated, children are much more engaged during reading because they can actively utilise their prior knowledge more efficiently. Thus, successful comprehenders tend to be imaginative readers and users of language who are able to actively select and organise information from complex texts (Block et al., 2002; Gambrell, 2004; Kamhi & Catts, 2002).

Working memory

Swanson, Howard, and Saez (2006) found that skilled comprehenders outperformed a range of poor comprehenders on measures related to working

memory. A number of other researchers have posited that, during reading, the ability to comprehend is enhanced when there is a reduction in the overall cognitive load in working memory (Daneman & Green, 1986; Manset-Williamson & Nelson, 2005; Pressley, 2002). It is asserted that memory load is affected by how attention is allocated within and between the different component subsystems of working memory during a particular reading episode (Achibald & Gathercole, 2007). Thus, the way a mental model is constructed may be largely determined by the architecture of memory and the reader's ability to effectively operationalise a number of processes simultaneously and to bind or link visual and verbal information in working memory.

One theoretical construct that is useful for conceptualising how attention is allocated in working memory was advanced originally by Baddeley and Hitch (1994) and further developed by Baddeley (2000). It was proposed that a central executive facility allocates attention resources for storage or processing and is responsible for temporary activation of information from long-term memory (Alloway, Gathercole, Willis, & Adams, 2004; Swanson, Howard, & Saez, 2006). This executive facility called the central executive is linked directly to two subsystems: the phonological loop and the visuospatial sketchpad. The phonological loop retains auditory information in time related serial order and is limited to what can be retained at any one time. It has an attention demanding sub-vocal rehearsal process that can be used to restore rapidly decaying verbal representations to keep them active while other working memory processes are operating. The visuospatial sketchpad is a second limited capacity slave system responsible for holding visual information. Unlike the phonological loop the visuospatial sketchpad holds visual information in the form of a spatial representation where each item can be displayed simultaneously (Allen, Baddeley, & Hitch, 2006; Alloway et al., 2004; Just & Carpenter, 1992). The efficiency of the two slave sub-systems is dependent on the exclusion of irrelevant material and the quality or intensity of the items retained (Cowan & Morey, 2006; Vogel, McCollough, & Machizawa, 2005). The episodic buffer is a third sub-system and it is also limited in terms of the number of episodes or chunks of material that it can hold concurrently (Allen et al., 2006). It is assumed that, within the buffer, representations from the two sub-systems and from long-term memory are bound in the form of episodic chunks. To be retrievable, the component representations must be adequately well linked (Alloway et al., 2004). Information is represented as conscious experience in the form of a developing mental model that also includes elements of both time and space (Boa, Li, & Zhang, 2007). It is asserted that many children who experience ongoing difficulties in constructing appropriate mental models of story information may have a deficit in the coordination and linking of information within working memory (Gathercole, Alloway, Willis, & Adams, 2006; Savage, Lavers, & Pillay, 2007; Swanson & Jerman, 2007).

Visualisation strategies

The efficiency of working memory can be improved by the incorporation of some structured inferential learning activities (Gathercole et al., 2006). In particular, a number of researchers have proposed that visual imagery techniques can be effective inferential learning strategies that can improve working memory efficiency by reducing the cognitive load associated with the mental modeling process (Joffe, Cain, & Maric, 2007; Sadoski & Willson, 2006; Woolley & Hay, 2004). Yuill and OakHill (1991) contended that inferential strategy instruction should improve working-memory efficiency because linked story information can be processed more economically. However, some researchers maintain that some instructional procedures can be counter productive because they can incorporate unnecessary cognitive activity that places heavy demands on working memory (McKeon, Beck, & Blake, 2009; Sweller, 1988). The concern is that some strategic processes will cause the learner to engage in extraneous cognitive processing that does not support learning (Stull & Mayer, 2007). For example, when word recognition is not automatic, letter-by-letter decoding will be attention demanding and interfere with reading comprehension. In situations like this executive processes will be involved in more active or conscious chunking as opposed to automatic chunking of information (Allen, Baddeley, & Hitch, 2006; Montgomery, Magimairaj, & O'Malley, 2008; Stull & Mayer, 2007). Initially the utilisation of any reading strategy may involve resource demanding conscious attention (Afflerbach, Pearson, & Paris, 2008). However, by developing a routine of stopping and discussing visualisations at three different phases in the reading lesson: before, during, and after reading (See Table 1) children are more able to practise the strategy until it becomes automatic. The expectation is that when they read independently they should focus on meaning (McKeon et al., 2009) and automatically visualise story content throughout the reading process. The assertion is that the use of a combination of visual and verbal strategies may initially be attention-demanding processes but can become automatic through explicit instruction and practised on a variety of texts (Woolley & Hay, 2004). A number of researchers have attested to the effectiveness of a range of different visualisation strategies. Some of these will be examined below.

Illustrations

Illustrations can compensate for weak listening comprehension skills in that they provide visual representations of main ideas and may also provide a visual summary, particularly for younger readers (Kendeou et al., 2009). Readers can also derive character depth and meaning from illustrations in picture books (Roser, Martinez, Fuhrken, & McDonnald, 2007). It has been shown that elaborated mental models are constructed and reading comprehension is enhanced when children are instructed to attend to story illustrations (Duke & Pearson, 2002; Van Meter, Aleksic, Schwartz, & Garner,

2006). For example, Glenburg and Langston (1992) found that during the reading process reader's constructed and incorporated visual information from the illustrations into their mental models using read text information. They asserted that good illustrations help younger or less experienced readers by linking their background knowledge with the unfolding text ideas and filling in information not provided by the text. Van Meter, et al. (2006) have suggested that, when illustrations are provided, verbal and nonverbal representations are organised in working memory and are then linked or bound to enhance mental modeling. Hibbing and Rankin-Erickson (2003) maintained that older and more able readers tend to naturally visualise story content and rely less on illustrations than younger or less skilled readers.

Drawing

A number of researchers have also suggested that drawing could also enhance the construction of elaborated mental models (Kintsch, 1994). Van Meter, et al. (2006) maintained that drawing was strategic because it is a goal-directed activity that enables improved reading comprehension through the organisation of knowledge. Furthermore, the researchers found that learners who made drawings engaged in more self-monitoring behaviours than learners who did not draw. They suggested that when readers draw, selected elements are organised to construct a mental model as the learner activates prior knowledge to connect with new understandings.

Van Meter et al. (2006) maintained that the integration of knowledge is different when learners read and draw rather than when they read and examine illustrations. The assumption is that when illustrations are provided, the verbal and imaginal representations in working memory are organised and then linked to form the mental model (Van Meter, et al., 2006). However, in situations where the learner encounters concepts for which no stored visual impression exists the verbal description is used to generate online visual imagery. Perfetti, (2007) asserted that the quality of the word representations affects reading skill, including comprehension. Thus, one would expect that the descriptive richness in the read story together with the child's own extended vocabulary would influence the quality of the mental model being constructed. Descriptive text-based richness is crucial to the drawing strategy because it is the verbal representation that complements and possibly directs the construction of the nonverbal representations in memory (Van Meter, et al., 2006). Thus, drawing and the quality of language of the text base mutually reinforce one another.

Elaborated instructions can also direct a learner's attention to the structures that connect one feature to another (Van Meter, et al., 2006). Van Meter, et al. found that upper primary school participants learned more when the drawing strategy was used with supported dialogue. Thus, the nonverbal or visual representation may be complemented by the use of verbal descriptions

and directions. For example, when drawing, a learner may see the need to determine the specific location of an item. Such a realisation may lead to a reappraisal of the text and selection of specific verbal information to direct the learner's construction of a visual representation.

Manipulations

Roser et al. (2007) maintained that a story character's world could become more concrete, comprehensible, and more able to be discussed when objects, items, pictures, and maps are used in conjunction with read stories. Glenberg et al. (2007) found that having readers manipulate objects to emulate characters and their actions in a text greatly enhanced comprehension as measured by both recall and inference tests. The researchers maintained that manipulations enabled links of words to objects as well as requiring the reader to visualise story elements and relationships as directed by the narrative syntax.

Visualisation

Glenberg et al. (2007) observed that children retained visualised images when tested using texts connected to object manipulations several days later. Furthermore, a number of other researchers have also found that when readers used mental imagery as a strategy it has resulted in improved reading comprehension outcomes (Pressley, 2002; National Reading Panel, 2000; Sadoski & Quast, 1990). It is assumed that students' use of mental imagery actively links read text information to the reader's own background experiences and provides a memory strategy that enhances recall and comprehension of the text (Joffe et al., 2007; Kosslyn, 1976; Romeo, 2002). For example, Romeo (2002) found that when reading tutors read rich descriptive texts aloud, it enabled children to use enhanced visualisations that lead to improved comprehension. At a number of stages during the reading the tutors were instructed to stop and ask the children to visualise the story events and then discuss their images. Later, it was discovered that the children automatically imaged the text events during reading without prompting. It has been suggested that the associated focused discussion can enhance the vividness of mental imagery and improved comprehension (Woolley & Hay, 2004). Farah (1995) suggested that the vividness of mental imagery activated during reading increases reading engagement, possibly because imagery relies heavily on the activation and utilisation of past experience.

Characterisations

One effective way for readers to decipher a complex plot thread in narratives is to try and understand the protagonist's perspective through story events. For example, Emery, (1996) found that students who discussed the story from a character's perspective, after reading a passage, had more positive ratings on their re-telling of the story and were better able to identify the story's central

problem. The inter-relationships of the main characters, in particular, may provide coherence between several sub-plots or incidences within the narrative structure (Roser et al., 2007). Emery (1996) maintained that a 'characters' beliefs, desires, feelings, and thoughts are the glue that holds the story together' (p. 534). Roser et al. (2007) maintained that it is the inner character traits that give the most insights on story plots and themes. Characters are shaped by their contexts and are developed by the interaction with other characters, settings and plots. When children are encouraged to focus on character perspectives it guides them through their stories, helping them to understand plots and consider overall story themes (Roser et al., 2007). Wade, Buxton, and Kelly (1999) argued that readers' interest could also be further enhanced by enabling them to visualise the story content by identifying with the central character and mentally placing themselves in a story scene.

Younger children tend to place more importance on the actions of characters in their causal models of stories. In contrast, older readers are more able to focus on the mental states of characters and on the more abstract event features. Older children also seem to show a stronger tendency in establishing causal connections across story episodes and longer text discourse than younger children (Rapp, Van den Broek, McMaster, Kendeou, & Espin, 2007). Thus, skilled or older readers are more able to progress to lengthier, more complex books by encountering increasingly more well-developed characters that react to circumstances in more meaningful and predictable ways throughout the course of the narrative (Roser et al., 2007).

Text structure and organisation

In general, the ability to integrate contextual information within a text is important for comprehension because it helps the reader to build a coherent representation of a text's meaning (Kintsch, 1998; Van der Schoot, Vasbinder, Reijntjes, Horsley, & Lieshout, 2009). However, less skilled readers have more difficulty utilising overall text structure, such as grammatical and contextual meaning cues, and need to be encouraged to use their inferential skills when reading (Catts, Hogan, & Fey, 2003; Bishop, 1997; Bowyer-Crane & Snowling, 2005). In particular, such readers appear to have difficulty visualising story content at the local level of understanding and also have difficulty retelling the gist of stories at the more global level (Diehl, Bennetto, & Young, 2006; Pressley, 2002; Woolley & Hay, 2004).

Knowledge of a story or text structure is often one of the most important elements in the comprehension of the narrative (Marr & Gormley, 1982; Pearson, Roehler, Dole, & Duffy, 1992; Whaley, 1981a; 1981b). For a text to be processed and understood it must have a logical structure and contain cohesive devices to assist with the construction of mental models of the read text. For example, understanding time order sequences in text passages will help to facilitate the reader's ability to comprehend and logically organise the narra-

tive information (Morrow, 1985; Trabasso & Sperry, 1985). Understanding the causal connections, as they relate to an event, or sequence of events may also play an important role in establishing the coherence of a story (Renz, Lorch, Milich, & Lemburger, et al., 2003). Such structures are important cohesive devices that enable the global organisation and understanding of read text information because they incorporate the story theme or gist (Kintsch, 1982). Thus, the theme of the story has a critical role to play in the coherence of texts and the development of appropriate mental modeling of text information (Harris & Pressley, 1991; Zhang & Hoosain, 2001). Normally, skilled readers use the largest, most general existing schema frame to construct their mental models, by organising their stories into schemas with settings, plots, and episodes (Diehl et al., 2006). That is, a skilled reader may activate the most appropriate stored schema to facilitate the organisation of read text information together with the retrieval of linked memory information. In this way a skilled readers' comprehension of the read text is directly associated with, and influenced by, their own past experiences.

Smaller units within the text structure may also contribute to the enhancement of the mental model. For example, cohesive devices such as introductory paragraphs may help organise and introduce preceding frames and story lines. Diehl et al. (2006) maintained that an event's relative importance to a story increases with the number of causal connections. This makes it easier for the reader to form links with existing ideas about the story and helps the reader to relate the story information to prior knowledge. However, when elements within the text are less cohesive it can make it more difficult for the reader. For example, Meyer (1975) found that information further away from the main theme was generally forgotten faster than information with direct connections to the overall content structure. A number of researchers have found that graphic organisers can link global conceptualisations of the text and story structure, particularly when used as a cooperative group activity where discussion of related ideas can take place (Nesbit & Adesope, 2006; Van Boxtel, Van der Linden, Roelfs, & Erkens, 2002).

The use of visualisation and verbal strategies within an intervention framework (see Table 1) may partly be determined by how suitable they are for the readers' stage of development and at what phase they are used in the reading lesson. Table 1 has been included to provide an example of a flexible multiple-strategy framework to show how and when these two aspects can be orchestrated within a lesson.

Multiple-strategy framework

In the past individual strategies have been introduced one at a time and children were unsure of when, where, and how to apply them to new reading situations (Pressley, 2002; Afflerbach et al., 2008). What is needed is the development of reading comprehension interventions that will enable skills to be

Table 1.
A flexible multiple-strategy framework
(incorporating some visualising strategies)

Phases	Processes	
	Visualising/local Scenes/events	Visualising/global Episodes/story
Before reading	Visualising similar scenes from similar background experiences to draw the opening scene of the story.	Using a graphic organiser to understand the structure of the text to be read. Asking questions to help elaborate drawn pictures.
During reading	Stopping at an appropriate place in the narrative and drawing a picture related to story events as the plot unfolds.	Asking and answering questions related to character actions and scenes as it relates to the drawings.
After reading	Making a summary drawing of the resolution scene.	Using the graphic organiser as a way to organise a summary by placing each of the three drawings in the appropriate space on the organiser and making an oral summary.
<i>N.B. The strategies used within this matrix are meant to be examples only and in practice they would be determined by factors such as skill level, stage of development and individual or group characteristics.</i>		

developed routinely and practised on a number of reading passages (Block, Paris, Reed, Whiteley, & Cleveland, 2009). A number of researchers have also emphasised that the simultaneous teaching of a combination of techniques needs to be a priority (NRP, 2000; Pressley, 2002). When considering what should be included, other researchers have suggested that both verbal and visual mental imagery techniques should be incorporated in the mix because it promotes inferential linking, deeper engagement, and interest in reading (Long, Winograd, & Bridge, 1989; Sadoski & Quast, 1990; Romeo, 2002; Tobias, 1994). Although multiple-strategy interventions are not new, visualisation and verbal strategies have yet to be fully utilised and included in classroom reading comprehension practice (Pressley, 2002).

Linking visual and verbal strategies

Many executive function difficulties can be attributed to difficulties in the ability to use language to organise one's thinking and behaviour (Leekam, 2007). For example, vocabulary knowledge underlies all learning and is one of the most significant predictors of reading comprehension. However, the acquisition of vocabulary and its usefulness depends on the quality of word representations and the way in which they are encoded and linked in working memory (Perfetti, 2007; Van der Schoot, Vasbinder, Reijntjes,

Horsley, & Lieshout, 2009). Blachowicz, Fisher, and Ogle (2006) maintained that the ability to make inferences is a crucial component in learning the meaning of new words and in reading comprehension. They suggested that having students make semantic connections among words, and verbalising or explaining those connections, supports learning their meanings. Moreover, Van Boxtel, Van der Linden, Roelfs, and Erkens (2002) suggested that making a concept map during a reading lesson helps learners develop the depth of word meanings and contributes to the development of an integrated mental model. They asserted that, when used in a collaborative setting, focused discussion enhances students' understandings and develops the quality and depth of their word representations (also Perfetti, 2007).

It has been demonstrated that, when reading and thinking processes are taught to students through dialogic interactions, they increase students' engagement and control of the reading comprehension process (Cole, 2002; Guthrie & Davis, 2003; Hareli & Weiner, 2002; Whitehurst & Lonigan, 1988). Higher student achievement and more positive social, motivational, and attitudinal outcomes have also been found to occur in collaborative learning contexts (Gambrell, Malloy, & Mazzoni, 2007; Overett & Donald, 1998; Woolley, 2007). The involvement of students in group discussions during and after listening to a story has been shown to lead to improved comprehension, particularly when the teacher asks questions or prompts students to describe what they have read (Gambrell, Mazzoni, & Almasi, 2000). Directed questions may also contribute to reading comprehension by focusing attention on text segments containing information being sought (Taboada & Guthrie, 2006). Explanatory answers to those questions can further improve the students' comprehension of read text and enable a more efficient use of language through focused dialogue (Snow, 2002). Thus, requiring students to self-explain during rereading will promote active learning that has been shown to lead to a significant improvement in self-monitoring for all the readers (Griffin, Wiley, & Thiede, 2008).

Self-regulation and engagement

Effective comprehension strategy users are metacognitively aware and have control of the reading process by being flexible in adapting their actions as they read. In doing so they make deliberate, goal directed attempts to gain meaning when they read (Afflerbach et al., 2008). A metacognitive focus involves active and reflective engagement in reading. It often involves a collaborative approach incorporating techniques such as questioning and peer assisted learning in which children adopt collaborative roles to corporately analyse texts (McKeon et al., 2009; Pressley et al., 2006). Such techniques can be augmented by other strategies such as: comprehension monitoring, self-explanations, mental imagery, identification of the main idea, previewing, predicting, and summarising text etc. (Kirby & Savage, 2008). Zimmerman

(2002) suggested that a metacognitive focus would lead to self-regulation. He maintained that self-regulation could be simply viewed as having three phases whereby learners set goals, monitor progress, and reflect on learning. Self-regulation techniques should be incorporated in instructional intervention frameworks to support the integration of new and existing strategies. In Table 2 the three self-regulation phases have been incorporated to show how they can be linked to the before, during, and after phases of the framework and how they can be associated with some visual and verbal strategies.

Glenburg and Langston (1992) found positive results for reading comprehension when readers were encouraged to focus on illustrations and to use self-questioning strategies about story events. Other researchers have also found that students who compose and answer their own questions were perceived as taking a more strategic and self-regulatory role in the learning process (Palincsar & Brown, 1984). Taboada & Guthrie, (2006) maintained that higher order questions were associated with high levels of conceptual knowledge gained from text, showing a clear correlation with questioning levels and reading higher comprehension outcomes. The researchers suggested that reading comprehension could be greatly enhanced when students are taught to ask questions that go beyond the literal level and require integration of information between the text and the reader's prior knowledge.

Taboada and Guthrie (2006) postulated that students who tend to ask lower order questions focus more on the local level information and struggle with identifying the overall global text structure. It was assumed that higher order questions enable the reader to connect their prior knowledge to the text base more easily for several reasons. These questions anticipate a possible macrostructure of the mental model that includes the major interrelationships among the concepts within the story. The reader, who asks high-order questions, preconstructs a mental model into which the text base can be more easily integrated. Thus, higher order questions tend to organise and represent knowledge built from text into hierarchical cognitive structures. Readers, who ask high order, conceptual questions are more able to anticipate and bring to the text an elaborated global structure. Such readers tend to build fuller text representations and richer mental models, characterised by a larger number of connections and relationships among the major concepts in the text and with their background knowledge (Kintsch, 1998). When students are instructed to ask their own questions it enables them to enter into a deeper interaction as they ponder relationships among different aspects of the text. As a result, they are more able to selectively use attention to focus on different sections of the text, develop main ideas, hypothesise about content, make predictions about upcoming information, and monitor their own comprehension. For example, when they are reading they may ask themselves questions such as 'Does this make sense?' If it does not make sense, they apply suitable repair strategies to restore comprehension (Van der Schoot et al., 2009).

Table 2.
A flexible metacognitive framework
(incorporating some metacognitive strategies)

Phases	Processes		
	Visualising/local Scenes/events	Visualising/global Episodes/story	Self-regulation and self-questioning
Before reading	Visualising similar scenes from similar background experiences to draw the opening scene of the story.	Using a graphic organiser to understand the structure of the text to be read. Asking questions to help elaborate drawn pictures.	<i>Goal setting</i> What do I think will happen in this Story? Visualise likely scenarios
During reading	Stopping at an appropriate place in the narrative and drawing a picture related to story events as the plot unfolds.	Asking and answering questions related to character actions and scenes as it relates to the drawings.	<i>Monitoring meaning/self-questioning</i> Is the story similar to what I imagined at the beginning? How is it the same/different? What do I think will happen now? Visualise a revised scenario.
After reading	Making a summary drawing of the resolution scene.	Using the graphic organiser as a way to organise a summary by placing each of the three drawings in the appropriate space on the organiser and making an oral summary.	<i>Reflection on strategies used.</i> What can I imagine now that I have come to the end? Were my predictions accurate? What was expected/unexpected? What else could I have considered?
<i>N.B. As language is instrumental in organising thinking and vocabulary learning it is important that there is a great deal of discussion to link visual imaginal representations with verbal conceptual understandings.</i>			

Summary

Successful comprehenders construct mental models that incorporate elaborated text based information with their available prior knowledge. Mental models are flexible representations that are constantly updated to reflect the most recent conceptualisations of read text information. However, the ability to form adequate mental models may be largely determined by the efficiency of working memory in allocating resources effectively. The ability to coordinate and allocate limited resources is vitally important to effective reading and comprehension. Visual and verbal instructional techniques can help overcome cognitive capacity limitations by utilising the subsystems of working memory more efficiently. Thus, reading comprehension is enhanced when visual and verbal information is utilised and linked in the working memory. When children are encouraged to visualise story content and to enter

into dialogue with others it elaborates and deepens the quality of their mental representations. It also enables the reader to make connections between verbal and visual content in a much more integrated way. Thus, the quality of a reader's mental model will be enhanced by the quality of the linking of information within working memory.

Despite the efficacy of visual and verbal comprehension strategies, they have not as yet been used extensively in multiple-strategy interventions programs. However, there are a number of evidence based visualising strategies that can be employed in intervention programs to enhance the local and global levels of understanding. The implication is that positive literacy outcomes for readers with comprehension difficulties will result when visual and verbal comprehension strategies are employed in a well coordinated reading intervention framework. It is important to use a number of strategies in an intervention framework and to apply these strategies routinely over several reading episodes to consolidate those strategies and to develop automaticity. Strategy use will be enhanced when readers are encouraged to actively monitor and reflect on the comprehension process by using self-questioning and self-explanations. Moreover, when applied in an interactive collaborative context, self-regulation and reading engagement will be promoted.

Acknowledgement

This submission has had research support from the Faculty of Education, Griffith University, Australia.

References

- Achibald, L.M.D., & Gathercole, S.E. (2007). The complexities of complex memory span: Storage and processing deficits in specific language impairment. *Journal of Memory and Language*, 57, 177–194.
- Afflerbach, P., Pearson, D., & Paris, S.G. (2008). Clarifying differences between reading skills and reading strategies. *The Reading Teacher*, 61(5), 364–373.
- Allen, R.J., Baddeley, A.D., & Hitch, G. J. (2006). Is the binding of visual features in working memory resource demanding? *Journal of Experimental Psychology*, 135(2), 298–313.
- Alloway, T.P., Gathercole, S.E., Willis, C., & Adams, A. (2004). A structural analysis of working memory and related cognitive skills in young children. *Journal of Experimental Child Psychology*, 87, 85–106.
- Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in cognitive sciences*, 4(1), 417–423.
- Baddeley, A.D., & Hitch, G. (1994). Developments in the concept of working memory. *Neuropsychology*, 8, 485–493.
- Bao, M. Li, Z., & Zhang, D. (2007) Binding facilitates attention switching within working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 33(5), 959–969.

- Bishop, D.V.M. (1997). *Uncommon understanding: Development and disorder of language comprehension in children*. Hove, UK: Psychological Press.
- Blachowicz, C.L.Z., Fisher, P.J.L., & Ogle, D. (2006). Vocabulary: Questions from the classroom. *Reading Research Quarterly*, 41(4), 524–529.
- Block, C.C., & Johnson, R.B. (2002). The thinking process approach: Preparing students for the future comprehension challenges. In C. Collins Block, L.B. Gambrell, & M. Pressley (Eds.), *Improving comprehension instruction* (pp. 385–389). San Francisco: Jossey-Bass.
- Block, C.C., Paris, S.R., Reed, K.L., Whiteley, C.S., & Cleveland, M.D. (2009). Instructional approaches that signify increase reading comprehension. *Journal of Educational Psychology*, 101(2), 262–281.
- Bowyer-Crane, C., & Snowling, M.J. (2005). Assessing children's inference generation: What do tests of reading comprehension measure? *British Journal of Educational Psychology*, 75, 189–201.
- Catts, H.W., Hogan, T.P., & Fey, M.E. (2003). Subgrouping poor readers on the basis of individual differences in reading-related abilities. *Journal of Learning Disabilities*, 36, 151–164.
- Cole, J.E. (2002). What motivates students to read? Four literacy personalities. *The Reading Teacher*, 56, 326–336.
- Cowan, N., & Morey, C.C. (2006). Visual working memory depends on attentional filtering. *Trends in Cognitive Sciences*, 10(4), 139–141.
- Daneman, M., & Green, I. (1986). Individual differences in comprehending and producing words in context. *Journal of Memory and Language*, 25, 1–18.
- Diehl, J.J., Bennetto, L., & Young, E.C. (2006). Story recall and narrative coherence of high-functioning children with autism spectrum disorders. *Journal of Abnormal Child Psychology*, 34(1), 87–102.
- Duke, N.K., & Pearson, P.D. (2002). Effective practices for developing reading comprehension. In A.E. Farstrup & S.J. Samuels (Eds.), *What research has to say about reading instruction*, (3rd ed., pp. 205–242). Newark, DE: International Reading Association.
- Emery, D.W. (1996). Helping readers comprehend stories from the characters' perspectives. *The Reading Teacher*, 49, 534–541.
- Farah, M.J. (1995). Current issues in the neuropsychology of image generation. *Neuropsychologia*, 33, 1455–1471.
- Fielding-Barnsley, R., Hay, I., & Ashman, A. (2005). *Phonological awareness: Necessary but not sufficient*. Paper presented at the National Conference of the Australian Association of Special Education, Brisbane, September, 2005.
- Gambrell, L.B. (2004). Exploring the connection between oral language and early reading. *The Reading Teacher*, 57, 490–492.
- Gambrell, L.B., Malloy, J.A., & Mazzoni, S.A. (2007). Evidence-based best practice for comprehensive literacy instruction. In L.B. Gambrell, L.M. Morrow, & M. Pressley (Eds.), *Best Practices in Literacy Instruction* (3rd ed., pp. 11–29). NY: The Guilford Press.
- Gambrell, B., Mazzoni, S.A., & Almasi, J.F. (2000). Promoting collaboration, social interaction, and engagement. In L. Baker, M.J. Dreher, & J.T. Guthrie (Eds.), *Engaging young readers: Promoting achievement and motivation* (pp. 119–139). New York: Guilford Press.

- Gathercole, S.E., Alloway, T.P., Willis, C., & Adams, A. (2006). Working memory in children with reading disabilities. *Journal of Experimental Child Psychology*, 93, 265–281.
- Gough, P.B., & Tunmer, W. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, 7, 6–10.
- Glenberg, A. M., Brown, M., & Levin, J. R. (2007). Enhancing comprehension in small reading groups using a manipulation strategy. *Contemporary Educational Psychology*, 32, 389–399.
- Glenberg, A.M., & Langston, W.E. (1992). Comprehension of illustrated text: pictures help to build mental models. *Journal of Memory and Language*, 31, 129–151.
- Griffin, T.D., Wiley, J., & Thiede, K.W. (2008). Individual differences, rereading, and self-explanation: Concurrent processing and cue validity as constraints on metacomprehension accuracy. *Memory & Cognition*, 36(1) 93–104.
- Guthrie, J.T., & Davis, M.H. (2003). Motivating the struggling readers in middle school through an engagement model of classroom practice. *Reading and Writing Quarterly*, 19, 59–85.
- Hareli, S., & Weiner, B. (2002). Social emotions and personality inferences: A scaffold for a new direction in the study of achievement motivation. *Educational Psychologist*, 37, 183–193.
- Harris, K.R., & Pressely, M. (1991). The nature of cognitive strategy instruction: Interactive strategy instruction. *Exceptional Children*, 57, 392–404.
- Hibbing, A.N., & Rankin-Erikson, J.L. (2003). A picture is worth a thousand words: Using visual images to improve comprehension for the middle school struggling readers. *The Reading Teacher*, 56, 758–770.
- Idol, L. (1988). Johnny can't read: Does the fault lie with the book, the teacher, or Johnny? *Remedial and Special Education*, 19, 8–25.
- Joffe, V.L., Cain, K., Maric, N. (2007). Comprehension problems in children with specific language impairment: Does mental imagery training help? *International Journal of Language & Communication Disorders*, 42(6), 648–664.
- Just, M.A., & Carpenter, P.A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychology Review*, 99, 122–149.
- Kamhi, A., & Catts, H. (2002). The language basis of reading: Implications for classification and treatment of children with reading disabilities. In K.G. Butler & E. Silliman (Eds.), *Speaking, reading, and writing in children with language learning disabilities: New paradigms in research and practice* (pp. 45–72). Mahwah, NJ: Lawrence Erlbaum Pub.
- Kendeou, P., Savage, R., Van den Broek, P. (2009). Revising the simple view of reading. *British Journal of Educational Psychology*, 79, 353–370.
- Kintsch, W. (1994). Text comprehension, memory and learning. *American Psychologist*, 49, 294–303.
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.
- Kintsch, W. (1982). Memory for text. In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 186–204). NY: North Holland.
- Kirby, J.R., & Savage, J.S. (2008). Can the simple view deal with the complexities of reading? *Literacy*, 42(2), 75–82.

- Kosslyn, S.M. (1976). Using imagery to retrieve semantic information: A developmental study. *Child Development*, 47, 434–444.
- Leekam, S. (2007). Language comprehension difficulties in children with autism spectrum disorders. In C. Cain and J. Oakhill (Eds.), *Children's Comprehension Problems in Oral and Written Language: A Cognitive Perspective* (pp. 104–127). NY: Guilford Press.
- Long, S.A., Winograd, P.N., & Bridge, C.A. (1989). The effects of reader and text characteristics on imagery reported during and after reading, *Reading Research Quarterly*, 24, 353–372.
- McKeon, M.G., Beck, I. L., & Blake, R.G.K. (2009). Rethinking reading comprehension instruction: A comparison of instruction for strategies and content approaches. *Reading Research Quarterly*, 44(3), 218–253.
- Manset-Williamson, G., & Nelson, J.M. (2005). Balanced, strategic reading instruction for upper-elementary and middle school students with reading disabilities: A comparative study of two approaches. *Learning Disability Quarterly*, 28, 59–74.
- Marr, M.B., & Gormley, K. (1982). Children's recall of familiar and unfamiliar text. *Reading Research Quarterly*, 18, 89–104.
- Meyer, B.J.F. (1975). *The organization of prose and its effects on memory*. Amsterdam: North Holland.
- Montgomery, J.W., Magimairaj, B.M., & O'Malley, M.H. (2008). Role of working memory in typically developing children's complex sentence comprehension. *Journal of Psycholinguistic Research*, 7:331–354.
- Morrow, L.M. (1985). Retelling stories: A strategy for improving young children's comprehension, concept of story structure, and oral language complexity. *Elementary School Journal*, 85, 647–661.
- National Reading Panel (2000). *Teaching children to read: Report of the comprehension instruction subgroup to the National Institute of Child Health and Development*. Washington, DC: NICD.
- Nesbit, J.C., & Adesope, O.O. (2006). Learning with concept and knowledge maps: A meta-analysis. *Review of Educational Research*, 76(3), 413–448.
- Overett, J., & Donald, D. (1998). Paired reading: effects of a parent involvement program in a disadvantaged community in South Africa. *British Journal of Educational Psychology*, 68, 347–356.
- Palincsar, A.S., & Brown, A.L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, 1, 117–175.
- Pearson, D.P., & Johnson D.D. (1978). *Teaching reading comprehension*. New York: Holt, Rinehart and Winston.
- Pearson, P.D., Roehler, L.R., Dole, J.A., & Duffy, G.G. (1992). Developing expertise in reading comprehension. In S.J. Samuels & A.E. Farstrup (Eds.), *What research has to say about reading instruction* (pp.101–144). Newark: International Reading Association.
- Perfetti, C. (2007). Reading ability: Lexical Quality to Comprehension. *Scientific Studies of Reading*, 11(4), 357–383.
- Pressley, M. (2002). Comprehension instruction: What makes sense now, what might make sense soon. *International Reading Association Online Document*, Accessed from <http://www.readingonline.org/articles/handbook/pressley/index.html>.
- Pressley, M.G. (2006). *Reading instruction that works: The case for balanced teaching* (3rd ed.). New York: Gilford Press.

- Rapp, D.N., Van den Broek, P., McMaster, K.L., Kendeou, P., & Espin, C.A. (2007). Higher order comprehension processes in struggling readers: A perspective for research and intervention. *Scientific Studies in Reading*, 11(4), 289–312.
- Renz, K., Lorch, E.P., Milich, R., Lemberger, C., Bodner, A., & Welsh, R. (2003). On-line story representation in boys with attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology*, 31(1), 93–105.
- Robinson, G. L. (2001). Problems in literacy and numeracy. In P. Foreman (Ed.), *Integration and Inclusion* (pp.167–229). Victoria: Nelson.
- Romeo, L. (2002). At-risk students: Learning to break through comprehension barriers. In C. Collins Block, L.B. Gambrell, & M. Pressley (Eds.), *Improving comprehension instruction* (pp. 385–389). San Francisco, Jossey-Bass.
- Roser, N., Martinez, M., Fuhrken, C., & McDonnold, K. (2007). Characters as guides to meaning. *The Reading Teacher*, 60(6), 548–559.
- Sadoski, M., & Quast, Z. (1990). Reader response and long-term recall for journalistic text: The roles of imagery, affect, and importance. *Reading Research Quarterly*, 25, 256–272.
- Sadoski, M., & Willson, V.L. (2006). Effects of a theoretically based large-scale reading intervention in a multicultural urban school district. *American Educational Research Journal*, 43, 137–484.
- Savage, R., Lavers, N. & Pillay, V. (2007). Working memory and reading difficulties: What we know and what we don't know about the relationship. *Educational Psychology Review*, 19, 185–121.
- Snow, C.E. (2002). *Reading for understanding: Toward a research and development program in reading comprehension*. Santa Monica, CA: Rand Corp. Retrieved December 12, 2002, from <http://www.rand.org/publications/MR/MR1465/>
- Snowling, M., & Firth, U. (1997). Comprehesion in hyperlexic readers. *Journal of Experimental Child Psychology*, 42, 392–415.
- Stull, A., Mayer, R.E. (2007). Learning by doing versus learning by viewing: Three experimental comparisons of learner-generated versus author-provided graphic organisers. *Journal of Educational Psychology*. 99(4), 808–820.
- Swanson, H.L., Howard, C.B., & Saez, L. (2006). Do different components of working memory underlie different subgroups of reading disabilities? *Journal of Learning Disabilities*, 39(3), 252–269.
- Swanson, H.L., & Jerman, O. (2007). The influence of working memory on reading growth in subgroups of children with reading difficulties. *Journal of Experimental Child Psychology*, 96, 249–283.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12, 257–285.
- Taboada, A., & Guthrie, J.T. (2006). Contributions of student questioning and prior knowledge to construction of knowledge from reading information text. *Journal of Literacy Research*, 38(1), 1–35.
- Trabasso, T., & Sperry, L.L. (1985). Causal relatedness and importance of story events. *Journal of Memory and Language*, 24, 595–611.
- Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of Educational Research*, 64, 37–54.

- Van Boxtel, C., Van der Linden, J., Roelofs, E., & Erkens, G. (2002). Collaborative concept mapping: Provoking and supporting meaningful discourse. *Theory Into Practice*, 41(1), 40–46.
- Van der Schoot, M., Vasbinder, A.L., Horsley, T.M., Reijntjes, A., & Van Lieshout, E.C.D.M. (2009). Lexical ambiguity resolution in good and poor comprehenders: An eye fixation and self-paced reading study in primary school children. *Journal of Educational Psychology*, 101(1), 21–36.
- Van Meter, P., Aleksic, M., Schwartz, A., & Garner, J. (2006). Learner-generated drawing as a strategy for learning from content area text. *Contemporary Educational Psychology*, 31, 142–166.
- Vogel, E.K., McCollough, A.W., & Machizawa, M.G. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature*, 438, 500–503.
- Wade, S.E., Buxton, W.M., & Kelly, M. (1999). Using think-alouds to examine reader text interest. *Reading Research Quarterly*, 34, 194–216.
- Whaley, J.F. (1981a). Readers' expectation for story structures. *Reading Research Quarterly*, 17, 90–114.
- Whaley, J.F. (1981b). Story grammars and reading instruction. *Reading Teacher*, 34, 762–771.
- Whitehurst, G.L., & Lonigan, C.J. (1988). Child development and emergent literacy. *Child Development*, 69, 848–872.
- Woolley, G.E. (2007). A comprehension intervention for children with reading comprehension difficulties. *Australian Journal of Learning Difficulties*, 12(1), 43–50.
- Woolley, G.E. (2006). Comprehension difficulties after year 4: Actioning appropriately. *Australian Journal of Learning Difficulties*, 11(3), 125–130.
- Woolley, G.E., & Hay, I. (2004). Using imagery as a strategy to enhance students' comprehension of read text. In B.A. Knight & W. Scott (Eds.), *Learning difficulties: Multiple perspectives* (pp. 85–101). Frenchs Forest, NSW: Pearson.
- Yuill, N., & Oakhill, J. (1991). *Children's problems in text comprehension*. Cambridge: Cambridge University Press.
- Zhang, H., & Hoosain, R. (2001). The influence of narrative text characteristics on thematic inference during reading. *Journal of Research in Reading*, 24, 173–186.
- Zimmerman, B.J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41, 64–70.